

ORIGINAL ARTICLE

Biological risk indicators for recurrent non-specific low back pain in adolescents

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Objectives: A matched case-control study was carried out to evaluate biological risk indicators for recurrent non-specific low back pain in adolescents.

Methods: Adolescents with recurrent non-specific low back pain (symptomatic; $n = 28$; mean (SD) age 14.9 (0.7) years) and matched controls (asymptomatic; $n = 28$; age 14.9 (0.7) years) with no history of non-specific low back pain participated. Measures of stature, mass, sitting height, sexual maturity (Tanner self assessment), lateral flexion of the spine, lumbar sagittal plane mobility (modified Schöber), hip range of motion (Leighton flexometer), back and hamstring flexibility (sit and reach), and trunk muscle endurance (number of sit ups) were performed using standardised procedures with established reliability. Backward stepwise logistic regression analysis was performed, with the presence/absence of recurrent low back pain as the dependent variable and the biological measures as the independent variables.

Results: Hip range of motion, trunk muscle endurance, lumbar sagittal plane mobility, and lateral flexion of the spine were identified as significant risk indicators of recurrent low back pain ($p < 0.05$). Follow up analysis indicated that symptomatic subjects had significantly reduced lateral flexion of the spine, lumbar sagittal plane mobility, and trunk muscle endurance ($p < 0.05$).

Conclusions: Hip range of motion, abdominal muscle endurance, lumbar flexibility, and lateral flexion of the spine were risk indicators for recurrent non-specific low back pain in a group of adolescents. These risk indicators identify the potential for exercise as a primary or secondary prevention method.

Epidemiological studies over the last 20 years from both Europe and the United States have provided evidence to suggest that children aged 9–18 experience non-specific low back pain (NSLBP). Two reviews evaluating the evidence on NSLBP prevalence in children indicate a cumulative lifetime prevalence of 28.7% (range 30–51%), a cumulative point prevalence of 12.6% (range 12–33%), and a cumulative recurrent prevalence of 8.1% (range 3–15%).^{1,2} Of particular concern is a recent report that identified increasing prevalence of NSLBP in children from surveys conducted in Finland between 1985 and 2001.³ The authors suggested that this finding indicated a new disease burden of degenerative musculoskeletal disorders in future adults. Furthermore, there is evidence that a subgroup of children experience severe and regular NSLBP that can be classified as recurrent NSLBP.^{4–6} The consequences of recurrent NSLBP in children include the use of medication, medical practitioner visits, and loss of participation in physical activity.^{6–8} Moreover, longitudinal research suggests that recurrent NSLBP during adolescence may lead to increased recurrence of NSLBP during adulthood, along with increased medical consequences and reduced work capacity.^{7,9}

Understanding the aetiology of recurrent NSLBP in adolescents may provide insight into NSLBP in adults,^{10–12} and quantifying the causes and consequences of NSLBP during childhood is fundamental to a fuller understanding of the problem.^{8,13,14} Extensive epidemiological evidence has indicated that there is not a single cause for NSLBP during childhood; instead a series of risk indicators give rise to an increased risk of NSLBP.^{1,2}

The risk of developing NSLBP appears to be multifactorial, although the current evidence on risk indicators for NSLBP is limited by the classification of the NSLBP cases. Risk indicators have been identified for children who have experienced a lifetime prevalence of NSLBP,^{10,15–18} one month prevalence of NSLBP,¹⁴ NSLBP in the previous six months,^{19,20}

and one year incidence of NSLBP.^{21–23} When evaluating risk indicators for NSLBP in children, there is a clear rationale to focus on the subgroup of children with recurrent NSLBP as this condition leads to greater disabling consequences and may track into adulthood low back pain. Only a few investigations have specifically considered the frequency and severity of the NSLBP when evaluating the risk indicators for NSLBP in children.^{6–8,12,24,25}

From the existing literature on risk indicators for recurrent NSLBP in children, there is limited evidence to suggest that biological factors, such as spinal mobility and trunk muscle endurance, are risk indicators.¹¹ Indeed two investigations were concerned with biological risk indicators but were based on self reported fitness⁸ or a crude categorical scale of mobility.⁷ Instead the focus has tended to be on psychosocial factors such as smoking,^{7,12,25} part time employment,⁷ psychosomatic stress,^{8,12} and tiredness in the morning.⁸ The aim of this investigation therefore was to evaluate biological risk indicators for recurrent non-specific low back pain in adolescents.

METHODS

Research design and subjects

The first stage of the study was a questionnaire based survey designed to assess the prevalence of NSLBP.²⁶ From this first stage, 42 adolescents aged 14–16 years who fulfilled criteria for the presence of recurrent NSLBP were identified. Recurrent NSLBP was classified as repeated acute episodes experienced as multiple spells. Of the 42 adolescents, 28 agreed to participate and completed all of the tests. χ^2 analysis indicated no significant difference in the frequency or perceived consequences of the NSLBP reported in the questionnaire between the consenting and non-consenting participants ($p < 0.05$). A follow up interview of the 28 patients with recurrent NSLBP established that 32% of them had sought medical attention ($n = 9$), 46% had been

prevented from participating in sports or physical activity ($n = 13$), and 32% ($n = 9$) had been absent from school as the result of NSLBP. The asymptomatic controls were matched to the symptomatic subjects for chronological age, sex, and school class. To obtain the asymptomatic sample, class lists were observed and children of the same sex and in the same school form as the symptomatic participants and who reported no history of NSLBP in the questionnaire were approached about the study. A total of 39 children were approached to gain consent of 28 appropriate children (two were excluded because follow on interview identified some history of NSLBP).

The sample therefore consisted of 28 adolescents with recurrent NSLBP (symptomatic; 15 boys, 13 girls; mean (SD) age 14.9 (0.7) years, stature 163.2 (7.0) cm, mass 58.4 (6.5) kg) and 28 matched controls with no history of low back pain (asymptomatic; 15 boys, 13 girls; age 14.9 (0.7) years stature 164.1 (7.9) cm, mass 55.0 (8.1) kg). All subjects were involved in a series of measures, obtained by the same experimenter. The experimenter was not blinded to group allocation, although the group allocation was not observed at the time of testing.

Measurements

Once the subjects had been identified, a series of measures were taken. Liverpool John Moores University Ethics Committee granted ethical approval for the study. Written informed parental consent and subject verbal assent were obtained before testing.

Anthropometric measures

Stature, mass, and sitting height were measured following standardised procedures to the nearest 0.1 cm, 0.1 kg, and 0.1 cm respectively.²⁷ Body mass index was calculated (mass divided by stature² (kg/m²)). Skinfold measures were taken from four sites: biceps, triceps, suprailiac, and subscapular.²⁸ All measures were obtained using calibrated Harpenden skinfold callipers (Quinton Instruments, Seattle, Washington, USA). The sequential measurement was duplicated at each site, and the mean calculated. The sum of four skinfolds was used as the composite measure.

Sexual maturity

Sexual maturity was measured using a self assessment procedure. Each subject was asked to observe drawings of the stage of secondary sex characteristics during puberty.²⁹ For the female subjects, these consisted of representations of five stages of breast development (frontal and lateral) and four stages of pubic hair development. For the male subjects, five stages of genital development (frontal) and four stages of pubic hair development were observed. The subjects were asked to view the drawings carefully and decide which stage most reflected their current status. A separate stage was recorded for breast development and pubic hair, or genital development and pubic hair, for female and male subjects respectively.

Flexibility/spinal mobility measures

Measures were taken using the modified Schöber procedure for lumbar flexion, side bending for lateral flexion of the spine, the Leighton Flexometer for hip range of motion with the knee extended, and the sit and reach test. Procedures followed were identical with those performed in a reliability study reported elsewhere.³⁰

Abdominal muscle endurance

Abdominal muscle endurance was assessed using the 60 second sit up test following standardised procedures identified in the reliability study.³⁰

Statistical analysis

Statistical analysis was performed using SPSS for Windows (version 10.1). Backward conditional stepwise logistic regression was performed because the dependent variable (presence/absence of recurrent NSLBP) was dichotomous. The predictor variables included in the model were sitting height, body mass index, sum of four skinfolds, pubic hair rating, genital rating, sit and reach, hip range of motion, lumbar flexibility in the sagittal plane, lateral flexion of the spine (composite of right and left side), and trunk muscle endurance. At each step, variables were excluded with a significance of $p > 0.10$. The significance of each coefficient within the model was evaluated using Wald tests. The fit of the regression equation was tested using the Hosmer-Lemeshow goodness of fit and χ^2 analysis. The risk indicators of recurrent NSLBP identified from the logistic regression were then analysed in a univariate analysis. A two way analysis of variance was performed for each risk indicator to assess the magnitude of the difference between the symptomatic and asymptomatic groups and to investigate the effect of sex. Significance was set at $p < 0.05$ for the univariate analysis.

RESULTS

Logistic regression analysis

Table 1 summarises the descriptive statistics for all variables entered into the logistic regression analysis. The logistic regression identified hip range of motion, number of sit ups, lumbar flexibility, and lateral flexion of the spine as significant risk indicators of recurrent NSLBP in adolescents (table 2). The Hosmer and Lemeshow goodness of fit test revealed no significant difference between the observed and expected predictions for low back pain. The percentage of correct predictions using the regression equation was 82.1%.

Univariate analysis

The two way analysis of variance and comparison of means identified that the symptomatic group had significantly lower abdominal muscular endurance, lumbar sagittal mobility, and lateral flexion of the spine than the asymptomatic group (table 2). The magnitude of the differences between the symptomatic and asymptomatic groups must be interpreted in relation to the measurement error associated with the variables.³⁰ The symptomatic subjects completed an average of 5.1 fewer sit ups than the asymptomatic subjects, which is similar in magnitude to the random error associated with the measure. The lateral flexion of the spine was an average of 23.1 mm lower for the symptomatic subjects than for the asymptomatic subjects; this value is greater than the measurement error associated with the measure. Likewise the lumbar flexibility was an average of 7.3 mm lower for the symptomatic subjects than for the asymptomatic subjects; this figure is greater than the measurement error associated with the measure. The two way analysis of variance for hip range of motion revealed no significant group effect. The lack of a significant difference could be related to the random error associated with the measure, the large variability, or the small sample size.

Significant sex effects were observed for all of the measures. The girls had increased flexibility and spinal mobility compared with the boys, but reduced abdominal muscle endurance ($p < 0.05$). The interaction effect provides an indicator of the interaction between the effects of sex and low back pain. No significant interaction effects were identified ($p > 0.05$), suggesting that risk indicators were similar for both sexes.

Table 1 Mean (SD) of all risk indicators entered into the logistic regression analysis

Measure	Boys		Girls		Group	
	Controls	RLBP	Controls	RLBP	Controls	RLBP
BMI (kg/m ²)	20.2 (1.3)	21.1 (1.3)	20.4 (2.3)	22.8 (1.8)	20.3 (1.8)	21.9 (1.8)
Genital Tanner stage	3.3 (1.0)	3.5 (0.6)	3.4 (0.9)	3.9 (0.8)	3.3 (0.9)	3.7 (0.7)
Hip ROM (°)	89.0 (4.1)	88.9 (5.5)	97.7 (8.8)	92.0 (8.1)	93.1 (7.9)	90.3 (6.9)
Lateral flexion of spine (mm)	215.7 (20.4)	188.0 (11.8)	226.4 (22.5)	208.6 (32.5)	220.7 (21.7)	197.6 (25.5)
Lumbar sagittal mobility (mm)	73.3 (9.3)	67.3 (8.5)	81.7 (6.8)	73.0 (7.9)	77.2 (9.1)	69.9 (8.6)
Number of sit ups	47.1 (7.0)	41.1 (5.9)	37.1 (6.6)	33.1 (4.3)	42.5 (8.4)	37.4 (6.5)
Pubic hair Tanner stage	3.0 (0.7)	3.4 (0.6)	3.5 (0.7)	3.8 (0.7)	3.2 (0.7)	3.6 (0.7)
Sit and reach (cm beyond toeline)	1.5 (2.3)	1.6 (2.8)	6.2 (4.6)	2.3 (3.5)	3.7 (4.2)	1.9 (3.1)
Sitting height (cm)	82.8 (4.8)	83.8 (4.6)	81.4 (3.5)	82.0 (3.2)	82.2 (4.2)	83.0 (4.1)
Sum of four skinfolds (mm)	28.0 (4.8)	29.9 (10.8)	38.9 (13.1)	41.2 (12.2)	33.0 (10.9)	39.8 (15.6)

RLBP, Subjects with recurrent low back pain; BMI, body mass index; ROM, range of motion.

DISCUSSION

The aim of the current matched case-control study was to evaluate biological risk indicators for recurrent NSLBP in adolescents. Given the aim, it is important to not only consider significance, but also to relate the findings to clinical importance while accounting for measurement error. Four biological risk indicators were identified for recurrent low back pain: hip range of motion, abdominal muscle endurance, lumbar flexibility, and lateral flexion of the spine.

Spinal mobility appears to be a risk indicator for developing recurrent NSLBP in the study population; this finding supports previous reports.^{11–31} In adult studies, it has been suggested that back muscles protect the underlying spine from excessive bending,³² and this protection is reduced by poor mobility.³³ The magnitude of difference between the groups suggests that the difference in spinal mobility cannot be attributed to measurement error. Restoration of mobility through exercise programmes may be possible in adults with low back pain,³⁴ whereas there is no evidence of this possibility in adolescents.

Hip range of motion was also identified as a risk indicator for recurrent NSLBP, which supports previous research.^{10–19} Hip range of motion appeared to be lower in the symptomatic group, although the two way analysis of variance revealed no significant difference between the groups. This finding seems to indicate that hip range of motion is the least important of the risk indicators identified. There is a scientific rationale for a limited hip range of motion being a risk indicator for low back pain, as flexibility of this joint facilitates spine conserving postures.³⁵

Abdominal muscle endurance was identified as a risk indicator for recurrent NSLBP; this observation supports previous research.¹¹ The symptomatic group had significantly lower abdominal muscle performance. It has been suggested that trunk muscle endurance has a prophylactic role in

preventing NSLBP in adults.³⁶ There is a strong scientific rationale for a link between trunk muscle endurance and low back pain, as adult studies have suggested that active motion of the lumbar spine is accomplished with large amounts of co-contraction in trunk flexor muscles.^{37–38}

Sitting height, body mass index, sum of skinfolds, and sexual maturity were not identified as significant risk indicators for recurrent NSLBP. Sitting height has not been previously examined in the specific child population of recurrent NSLBP cases but in lifetime prevalence cases has been identified as a significant risk indicator.^{10–23–39} It may be that the rate of change of sitting height is more predictive of low back pain than the absolute value, especially during the growth spurt.²³ Furthermore measures of leg length may be more appropriate in future research, as discrepancy between leg lengths can occur during the adolescent growth spurt. No previous research has examined the effect of adiposity on recurrent NSLBP in children, although body mass index has been identified as a risk indicator.⁷

When undertaking research into health issues, such as NSLBP, one must face the fact that the effects of the disease and its cause do not exist in isolation but in a complex interplay of many intervening factors. Consequently, it is difficult to determine if the risk indicators identified are causes of recurrent NSLBP or the effect of NSLBP. A longitudinal design would be best suited to identifying risk indicators associated with the onset and development of recurrent NSLBP. Future research should continue to evaluate risk indicators for recurrent and more severe NSLBP and should attempt to examine a full model including biological, psychosocial, and individual factors. On the basis of the current study, it seems that spinal mobility and trunk muscle endurance are key measures to include in future research. Additional biological measures such as muscular balance between the trunk flexors and extensors may also be

Table 2 Summary of the biological risk indicators analysis

Measure	Logistic regression		ANOVA group effect		Mean (SD)		95% Limits of agreement ³⁰
	Wald test	p Value	F _{1,52}	p Value	RLBP	Controls	
Hip ROM (°)	4.02	0.045*	2.626	0.111	93.1 (7.9)	90.3 (6.9)	−0.03 (5.72)
Lateral flexion of spine (mm)	7.02	0.008*	14.138	0.001*	197.6 (25.5)	220.7 (21.7)	−0.50 (16.93)
Lumbar sagittal mobility (mm)	4.58	0.032*	11.186	0.002*	69.9 (8.6)	77.2 (9.1)	0.90 (5.74)
Number of sit ups	10.82	0.001*	9.395	0.003*	37.4 (6.5)	42.5 (8.4)	−0.63 (5.25)

*Significant at p<0.05.

RLBP, Subjects with recurrent low back pain; ANOVA, analysis of variance; ROM, range of motion.

What is already known on this topic

NSLBP is a common and increasingly prevalent problem in adolescents. Cases of NSLBP during adolescence can become recurrent and debilitating. Evidence for a range of psychosomatic risk indicators exists for the development of recurrent NSLBP during adolescence, but there is little robust evidence for the presence of biological risk indicators.

What this study adds

Adolescents with recurrent NSLBP had significantly reduced lumbar sagittal mobility, lateral spinal flexion, and abdominal muscle endurance compared with matched controls. Spinal mobility and trunk muscle endurance are biological risk indicators for recurrent NSLBP in adolescents, indicating a potential role for exercise as a primary or secondary prevention strategy.

warranted in future research as there is a logical biological rationale,³⁵ and, although not convincing, previous research into NSLBP in both children⁴⁰ and adults⁴¹ has indicated muscular imbalance as a potential risk indicator for NSLBP.

Hip range of motion, abdominal muscle endurance, lumbar flexibility, and lateral flexion of the spine were the best predictors of recurrent NSLBP in a group of adolescents. Symptomatic subjects had significantly reduced spinal mobility and trunk muscle endurance compared with the asymptomatic group. This finding suggests that these risk indicators are the most important of the biological risk indicators examined. In contrast, sitting height, adiposity/overweight, and sexual maturity were not significant risk indicators in the current study. These risk indicators identify the potential for exercise as a primary or secondary prevention method.

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